

MASTER OF SCIENCE IN SOFTWARE ENGINEERING

AUTONOMOUS AGENTS FOR DIGITAL NETWORK MAXIMIZATION

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The advent of the computer age has brought about a plenitude of benefits to the human race. Included with these benefits has been the ever-increasing demand to transfer exponentially increasing amounts of information, and the associated problems of information sharing. The focus of this thesis has been to best utilize available digital communications assets in the radio frequency (RF) spectrum to allow sufficient transfer of information providing DoD assets flexible, rapid, and in-flight reprogramming, replanning of strike and cruise missile assets, to engage a high value, emergent target, in the shortest possible time. The postulated methods of utilizing autonomous agents to manage information flow across network nodes has applicability to all digital networks.

Based upon the pioneering work of Pattie Maes at Massachusetts Institute of Technology (MIT), and previous examination of communications node management, the implementation of independent processes working on behalf of a host system to optimize the effective meaningful throughput on a communications channel is not only desirable, but necessary. The evolution of semi-intelligent software, whether called Artificial Intelligence, Intelligent Agents, or Autonomous Agents, has reached a level of sophistication allowing the insertion of meaningful articulated processes within existing, and future systems to maximize the network efficiency systematically. Recent work by Michael Cohen on Sodabots, and the evolution of user interactive TinyMUDS of the Maas-Neotek family, a virtual type personality environment, has demonstrated the ability of software to deal with dynamic and changing conditions. The exponential increase in micro-processor power has, for the first time, made available the hardware for such agent implementations as compact, self contained, embedded systems, in direct support of larger existing systems.

INTRUSION DETECTION IN REAL TIME IN A MULTI-NODE, MULTI-HOST ENVIRONMENT

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While there exist many tools and methods used to recognize intrusions into single system environments, there are few that can recognize and handle attacks in real time. This group is further reduced when adding the complexity of recognizing and handling intrusions occurring in a heterogeneous networked environment. The results of the thesis are an open architecture design for a real-time intrusion detection system to handle intrusions in a heterogeneous network and the system requirements, specifications, protocols and software module design to support an implementation of a system using this architecture. The architecture presented herein comprises a distributed system of autonomous agents that reside on the various hosts in a network. These agents communicate with each other in a coordinated effort to identify and respond to intrusions into the network by sending messages to each other detailing the identity and threat level of a potential or imminent attack. To quantify the threat level of an ongoing attack, this thesis also presents an alert level hierarchy based on the danger level and transferability of the threat to the various hosts within the network.

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THE DOLPHIN DIDACTIC DATABASE SYSTEM (DODDS)

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The Naval Command, Control and Ocean Surveillance Center (NCCOSC) Research, Development, Test and Evaluation Division (NRaD) Marine Mammal Research Programs are conducted by the Marine Mammal Research & Development Branch (D35 1). Progeny is a project, under D351, that trains Atlantic Bottlenose Dolphins (*Tursiops Truncatus*). Progeny was designed to explore the standardization of training, husbandry, and record-keeping techniques that contribute to preparing, operating, and maintaining dolphins for Fleet systems.

Presently, hand-written forms are filled out to record data as trainers conduct their training exercises. These forms become the source for creating reports. The current data collection process is tedious, time-consuming, and potentially unmanageable for the staff.

This thesis project provides a means to organize, gather, and maintain all the historical, current, and future data for the Progeny project. Capabilities are needed to gather the data so that timely, meaningful information, such as reports and graphs, can be made accessible to the staff.

The deliverables from this study are the development of a relational database system for organizing and storing Progeny's data, and the development of an application for entering and accessing the data within the relational database. Output reports and graphs provide information from the data.

REAL-TIME EVENT EXECUTION MONITORING

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Currently the Computer-Aided Prototyping System software development environment provides monitoring techniques for real-time tasking execution times. However, these techniques are constrained in that there is only a provision for simple error messages to be presented upon execution failure such as that caused by a missed deadline. This approach necessitates that the software system designer haphazardly guess a task set execution time.

This thesis performed an examination of fine grain execution timing. This work was accomplished through the development of a program to perform true dynamic run time data collection of the typical task set execution exhibited within a real-time environment.

The results of this work is an accurate and efficient real-time task set execution monitoring software program which assists in overcoming the problem of task set execution run time prediction. The program itself has been embedded within the Computer-Aided Prototyping System environment and is an enhancement over the previous monitoring technique by providing the system designer with true and accurate run time execution times. The validation of the thesis work has been performed by successful design and development of time critical real-time prototype software within the Computer-Aided Prototyping System using the execution monitoring program.

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PROJECT SCHEDULING TOOL

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Optimally scheduling a team of developers on a large software project is an NP-complete problem. The scheduling algorithm employed by the Evolutionary Control System (ECS) portion of the Computer-Aided Prototyping System (CAPS) does near-optimal scheduling using an algorithm that runs in Order N^2 space and time. The problem addressed by this thesis is to improve the performance of the algorithm and make it more useful for scheduling software developers. The thesis accomplished three things: (1) modified the algorithm to run in order N time and space, preserving its near-optimal behavior; (2) implemented a calendaring package that computes federal holidays for any year after 1970 and schedules tasks only on non-holiday workdays; and (3) incorporated a more realistic capability model to better match programming tasks with each developer's abilities.

JAVA BASED DATA CONNECTIVITY

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Current web database connectivity solutions lack an object—oriented architecture for Java applications. In particular, Java is object—oriented and most legacy databases are relational. This thesis proposes a design and implementation of an object—oriented java database class hierarchy for relational database interfaces.

The work reported here consists of: analysis of Java Database Connectivity specification, discussion of two—tier and three—tier architectures for database systems, mapping of relation database structure to an object model, and development of a java based framework to exercise the JDBC interfaces.

This work provides (1): an object model for the relational database; (2) Integration with a middleware application for network connectivity; (3) A Java application client to support SQL access and manipulation.

IMPROVING SYNTACTIC MATCHING FOR MULTI-LEVEL FILTERING

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At the center of software reuse is the search and retrieval of software components from large software libraries. Recent research has illuminated a promising approach called multi-level filtering that breaks the problem up into a series of increasingly stringent filters that move along a continuum of high-recall, low-precision syntactic techniques towards the more computationally expensive, high-precision semantic techniques.

In multi-level filtering, syntactic matching is decomposed into two phases: profile filtering and signature matching. This thesis presents improvements to the resolution of syntactic profiles where the intent is to increase precision without a loss in recall during profile filtering. Large integer representation of profiles and profile lookup tables lead to an optimal time-and-space solution to profile representation. Finally, a new approach to signature matching is proposed that provides early pruning of the search-space in an effort to cut down the time it takes to find valid signature maps.

The resulting software is mature enough for future integration with the other elements of multi-level filtering as well as inclusion in a CASE tool such as CAPS.

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DECOMPOSITION RECOVERY EXTENSION TO THE COMPUTER-AIDED PROTOTYPING SYSTEM (CAPS) CHANGE-MERGE TOOL

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A promising use of Computer-Aided Prototyping System (CAPS) is to support concurrent design. Key to success in this context is the ability to automatically and reliably combine and integrate the prototypes produced in concurrent efforts. Thus, to be of practical use in this as well as most prototyping contexts, a CAPS tool must have a fast, automated, reliable prototype integration capability.

The current CAPS Change-Merge Tool is fast, automated, and uses a highly reliable formalized semantics-based change-merging method to integrate, or change-merge, prototypes which are written in Prototype System Description Language (PSDL). This method can guarantee correct merges, but it loses the prototype's design decomposition structure in the process. The post-merge prototype is fully functional, but the design decomposition structure vital to prototype understandability must be manually recovered before post-merge prototyping can continue. The delay incurred is unacceptable in a rapid prototyping context.

This thesis presents a software design and Ada implementation for a formalized algorithm which extends the current CAPS Change-Merge Tool to automatically and reliably recover a merged prototype's design decomposition structure. The algorithm is based in formal theoretical approaches to software change-merging and includes a method to automatically report and resolve structural merge conflicts. With this extension to the Change-Merge Tool, CAPS prototyping efforts, concurrent or otherwise, can continue post-merge with little or no delay.

A PRACTICAL GUIDE TO INTRANET PLANNING

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One problem an intranet planner faces is that it takes too long to research the subject. Initially, the intranet planner needs to get the "big picture"—not implementation details. This thesis will help the reader quickly grasp intranet concepts, terminology, and major issues, in order to save time in formulating an effective strategy. The thesis defines Internet, intranet, and extranet, from physical and organizational viewpoints, and introduces the issues discussed in later chapters. The control issue is shown to be the common theme in debates about centralized versus distributed computing, thin versus fat client, closed versus open access, supplier push versus user pull, and management control versus employee empowerment. There is a discussion of what Web technology does well, how to integrate it with existing technology, Java, and top-down versus bottom-up intranet development. Network architecture and firewalls are discussed, as well as, network security threats and what can be done to counter them.

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HYPERMEDIA ANALYSIS AND NAVIGATION OF DOMAINS

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Hypermedia systems have been demonstrated to support authoring and reading of mostly static information. Few systems address the needs of analysts deriving information from a continuously changing base of information. Those that do, focus on the existing content and use links primarily for navigation and management. An open hypermedia architecture is proposed for a class of analysis systems where the value added by the analyst is through associating data elements. In such systems, links are the primary form of information being managed.

The architecture developed provides a framework through which hypermedia analysis systems can be generated with little or no code development. Specifically, the model is shown to apply to the domain of software engineering by mapping the analysis portions of a rapid prototyping lifecycle to a schema defined using the framework.

Through the addition of n-ary links and links to links, the architecture provides a closer mapping to the Dexter Hypertext Reference Model than current graph-based models such as the Multimedia Object Retrieval Environment (MORE). Improvements over MORE are also shown in the use of abstraction as a filtering mechanism and through the full involvement of links as being the primary focus of the analysis, query, and filtering functions.

SPAWAR YEAR 2000 ASSESSMENT PHASE CASE STUDY

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This thesis involves a case study that surveys government systems within the Space and Naval Warfare Systems Command (SPAWAR) to (i) determine the Year 2000 impacts within their Department of the Navy (DoN) systems, (ii) compare this impact with current industry experience, (iii) evaluate the cost drivers used in estimating costs within the DoN and determine if these cost drivers are valid for use in estimating Year 2000 costs for SPAWAR systems, and (iv) evaluate the Assessment Phase process. In this case study it was observed that the SPAWAR systems were impacted in the same manner by the Year 2000 problem as private industry. The SPAWAR systems cost modeling will require calibration for unique Year 2000 cost drivers in addition to cost drivers unique to the Department of Defense. The Year 2000 Assessment Phase requires strong management support and a centralized Year 2000 office responsible for all aspects of a Year 2000 effort.

THE DESIGN OF AN INTERFACE EDITOR FOR THE COMPUTER-AIDED PROTOTYPING SYSTEM

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This thesis focuses on the design and implementation of a new interface editor for the Computer-Aided Prototyping System (CAPS), which de-couples the user interface from the real-time prototype. Using this design, a CAPS user creates a prototype with an interface development tool and a Prototyping System Description Language (PSDL) editor. This real-time prototype executes on two processors using a client/server architecture; the user interface executes on a client, and the real-time PSDL application executes on a server. In addition, this thesis includes demonstrations, with source code, which

implement the design. The demonstrations show that Java development tools can be used to create a high-quality user interface for a PSDL application. A socket connection was used to implement the client/server communication. The demonstrations were successful, but the socket programming model is too primitive for the new design. Therefore, a high-level client/server architecture, such as the Common Object Resource Broker Architecture (CORBA), is required for future development of the design.

